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STUDIES ON THE CONTROL OF REED CANARYGRASS ALONG IRRIGATION SYSTEMS

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PREFACE

The results of the investigations reported herein are as pertinent today as at the time the investigations were conducted (1960-64). They are released by this publication medium as a public service, as background information for those involved in similar research, and as a guide for developing practical methods of controlling reed canarygrass along irrigation systems.

All of the experiments were conducted near Toppenish, Wash. However, the findings should be applicable in many similar areas or regions wherein reed canarygrass is a problem.

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STUDIES ON THE CONTROL OF REED CANARYGRASS ALONG IRRIGATION SYSTEMS

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SUMMARY

Eleven separate experiments on the control of reed canarygrass along irrigation channels were conducted near Toppenish, Wash., on the Wapato Irrigation Project from 1961 through 1964.

When applied repeatedly, amitrole-T at 4 pounds per acre was as effective as amitrole at 8 or 12 pounds per acre and somewhat superior to dalapon at 15 to 25 pounds per acre in eliminating reed canarygrass. However, even after eight treatments in 3 years, a few shoots still survived at the waterline. Such survival is a source of rapid reencroachment and spread. Initial fall applications of the amitroles or dalapon were superior to initial spring applications. Repeated applications of MH at 4, 6, or 8 pounds per acre did not suppress the growth satisfactorily in the zone immediately above the waterline. None of the herbicides appeared to translocate readily in reed canarygrass.

Repeated applications of dalapon at 5, 10, or 15 pounds per acre did not suppress reed canarygrass effectively along an irrigation channel.

Dalapon at 20 pounds was about equally effective in controlling reed canarygrass whether the herbicide was applied in 40, 80, 160, or 320 gallons of water per acre.

The effect of dalapon on reed canarygrass when the herbicide was applied at 20 pounds in 100 gallons of water per acre on April 12 was not enhanced by the addition of kerosene at a rate of 0.5 percent (volume per volume). Further, the effect of dalapon was not enhanced by the addition of 10 different commercially formulated surfactants at concentrations of 0.06 and 0.125 percent.

The optimum time for initially applying amitrole-T at 4 pounds per acre in the spring was about May 1, when the reed canarygrass was approximately 3 feet high at the waterline and still in the preheading stage. To maintain effective control during the season, two retreatments were necessary when initial treatments were made before mid-April, whereas only one retreatment was needed when initial treatments were made between mid-April and late-May.

Under favorable moisture conditions, fall applications of TCA at 100, 130, or 160 pounds per acre nearly eliminated reed canarygrass. Seedings of desirable grasses the following spring resulted in dense stands. However, the few surviving plants at the waterline were growing profusely, were headed, and were spreading and lodging in the water by early summer of the 2d year after treatment. Under dry weather conditions, the TCA treatments were less effective in eliminating reed canarygrass, and no seedlings of desirable grasses emerged the following spring. The ester of TCA at 12.5, 25, and 50 pounds per acre did not effectively control reed canarygrass when applied in either a water or an oil diluent.

Treatments with paraquat at 2 pounds per acre controlled reed canarygrass more effectively than treatments with diquat at 2, 4, or 6 pounds per acre. However, none of the treatments were practical for controlling sizeable infestations of reed canarygrass along irrigation systems.

Of the eight persistent herbicides applied to reed canarygrass in late fall, dicamba produced toxicity symptoms most rapidly. However, dicamba did not completely eliminate the reed canarygrass at the waterline, even at 40 pounds per acre. Only atrazine at 40 or 80 pounds per acre, or isocil at 40 pounds per acre, eliminated all reed canarygrass within 2 years after application.

Foliar applications of diuron at 4.8 or 9.6 pounds or bromacil at 2.4 pounds in 300 gallons of water per acre, plus surfactant at the rate of 0.5 percent by volume of water, did not control reed canarygrass effectively.

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INTRODUCTION

Reed canarygrass (*Phalaris arundinacea* L.) is a perennial with creeping rhizomes that constitutes an important part of lowland hay and pasturage from Montana to Wisconsin. However, this same species has become one of the most serious weed problems along irrigation systems in the Pacific Northwest (fig. 1). It flourishes and produces an abundance of tall, rank growth under the moist conditions of such systems. Uncontrolled, the rank foliage topples into the channels, continues to grow, and impedes the water flow. Small irrigation laterals may become completely clogged by midseason (fig. 2). Berms develop rapidly. Even single clumps of reed canarygrass at the edge of large canals can cause berms that extend 3 to 4 feet into the water and necessitate mechanical removal at the end of the irrigation season.

On some irrigation projects, the canal banks have been scythed, mowed, or burned during the irrigation season to temporarily control reed canarygrass. On others, herbicides have been used with rather erratic results. In field experiments, Timmons and Lee (*6*)[2] found that some reed canarygrass survived fall applications of monuron at 120 pounds, polyborchlorate at 1920 pounds, or sodium chlorate at 960 pounds per acre. In suppression studies with contact herbicides, Yeo (*8*) reported that weed oil containing 55 percent aromatics was significantly more effective on reed canarygrass at 120 g.p.a. than 1,1-ethylene-2, 2-dipyridylium dibromide at 2 or 4 pounds per acre, the weed oil at 100 gallons plus sodium salt of pentachlorophenate at 2 pounds per acre, or a heavy burn.

FIGURE 1.—(*Left*), Reed canarygrass along an irrigation system; (*right*), dense root systems and creeping rhizomes of specimen plants.

The objectives of the experiments described in this report were (a) to evaluate the more promising herbicides for use on reed canarygrass, and (b) to establish guidelines for developing practical methods of controlling this grass and preventing its spread along irrigation systems.

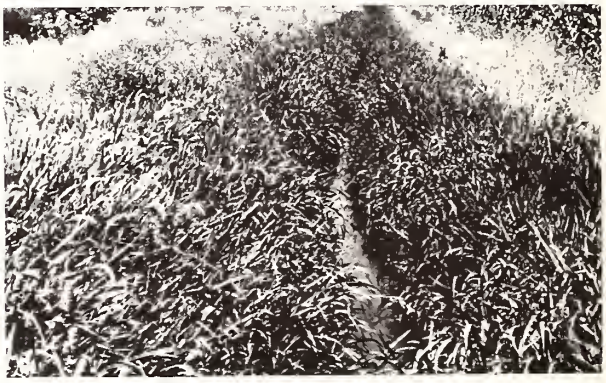

FIGURE 2.—Irrigation lateral almost completely clogged by reed canarygrass on July 1.

GENERAL CONDITIONS AND PROCEDURES

The experiments described in this report were conducted during 1960 through 1964. All experiments were conducted along irrigation channels infested with reed canarygrass near Toppenish, Wash., on the Wapato Irrigation Project. Infestations for the experiments were selected in accordance with uniformity of stand and accessibility. All plots were laid out in linear sequence and divided into three blocks. The plots were 8 1/4 feet wide and 16 1/2 feet long in all

[2]Italic numbers in parentheses refer to Literature Cited, p. 17.

but the 1963 experiment on date of applying amitrole-T. The lower edge of the plots began at the waterline.

Treatments were randomized within each of the three blocks. In all but the 1963 experiment, in which persistent herbicides were applied to the foliage, 3-gallon knapsack sprayers with fan-type nozzles and pressures of 25 to 30 pounds per square inch (p.s.i.) were used to apply the herbicides. The names of the herbicides tested in one or more of the experiments are given in table 1. Unless specified otherwise, surfactant (a commercial formulation of alkylarylpolyoxyethylene glycols, free fatty acids, and isopropanol) was added at the rate of 6 ounces per 100 gallons of herbicide spray. Whenever possible, evaluations of the percentage of reed canarygrass ground cover were made by at least two trained observers at the time of the initial treatments and at monthly intervals thereafter. Height and other measurements were taken when such data were considered helpful. Retreatments were made as necessary to attain the objectives of the experiment.

The climatological data presented herein were gathered and reported by the National Weather Service Station at Wapato, Wash.

TABLE 1.—Common or trade and chemical names of herbicides tested for the control of reed canarygrass

Common or trade name or symbol[1]	Chemical name
Amitrole	3-amino-*s*-triazole
Amitrole-T	3-amino-*s*-triazole plus ammonium thiocyanate
Atrazine	2-chloro-4-(ethylamino)-6-(isopropylamino)-*s*-triazine
Bromacil	5-bromo-3-*sec*-butyl-6-methyluracil
Dalapon	2,2-dichloropropionic acid
Dicamba	3,6-dichloro-*o*-anisic acid
Dichlobenil	2,6-dichlorobenzonitrile
Diquat	6,7-dihydrodipyrido[1,2-*a*:2',1'-*c*]pyrazinediium ion
Diuron	3-(3,4-dichlorophenyl)-1,1-dimethylurea
Fenac	(2,3,6-trichlorophenyl)acetic acid
Isocil	5-bromo-3-isopropyl-6-methyluracil
MH	1,2-dihydro-3,6-pyridazinedione
Monuron	3-(*p*-chlorophenyl)-1,1-dimethylurea
Paraquat	1,1'-dimethyl-4,4'-bipyridinium ion
Simazine	2-chloro-4,6-bis(ethylamino)-*s*-triazine
TCA	trichloroacetic acid
Ester of TCA	Diethyleneglycol ester of trichloroacetic acid
Sodium salt of TCA	Sodium trichloroacetate
2,4-D	(2,4-dichlorophenoxy)acetic acid

[1]Common names or symbols approved by the Terminology Committee of the Weed Society of America (*7*).

EXPERIMENTAL TREATMENTS AND RESULTS

Rate and Time of Applying Amitrole, Amitrole-T, Dalapon, and MH

During the course of the experiments, the water level in the laterals fluctuated. Thus, reed canarygrass within the zone of fluctuation grew as a bank, an emersed, and even a submersed weed at various times.

Treatments Started in the Spring

On April 18, 1960, amitrole at 4, 8, or 12 pounds per acre; amitrole-T at 2, 4, or 6 pounds per acre (amitrole basis); sodium salt of dalapon at 15, 20, or 25 pounds plus 2 pounds of the alkanolamine salts of 2,4-D per acre each; and the diethanolamine salt of MH at 4, 6, or 8 pounds plus 2 pounds of 2,4-D per acre each were applied to reed canarygrass along Drain Spur 53. Water was used as the diluent at the rate of 80 gallons per acre (g.p.a.).

The experiment was repeated on April 14, 1961, along Lateral 4 Extension. The MH treatments were omitted from the experiment started in the spring of 1961, and the rate of water as a diluent was increased to 160 g.p.a.

The reed canarygrass was dense, growing luxuriantly, and about 12 inches high at the time that the initial treatments were made. The first irrigation water of the spring was turned into the laterals a few days prior to the treatments. In Drain Spur 53, the ditchbanks were visibly saturated to 12 inches above the waterline. Some reed canarygrass shoots from below the waterline were submerged. In mid-August,

moist soil was present within 8 to 10 inches of the surface on the top of the bank. In Lateral 4 Extension, a berm 20 inches wide had developed at the waterline and constituted part of the plot area.

During the first year of the 1960 and 1961 experiments, the first retreatments were made near the end of June, and the second retreatments were made about mid-August. On those dates, the surviving reed canarygrass ranged in height from 3 inches on the top of the bank to 36 inches near the waterline. In the 1960 experiment, additional retreatments were made on April 14, June 29, and August 16, 1961; and April 23 and July 6, 1962. In the 1961 experiment, additional retreatments were made on April 12 and July 3, 1962. Both experiments were terminated on August 10, 1962.

Treatments Started in the Fall

On October 17, 1960, amitrole at 8 pounds, amitrole-T at 4 pounds, dalapon at 20 pounds, and MH at 6 pounds per acre were applied to reed canarygrass along Lateral 4 Extension 395. 2,4-D at 2 pounds per acre was included with the dalapon and MH treatments. Water was used as the diluent at 80 g.p.a. The experiment was repeated without the MH treatment on October 5, 1961, along Drain Spur 53.

In both experiments, the ditchbanks had been mowed during the summer and the regrowth on the inward slope of the banks was dense, luxuriant, and 10 to 18 inches high at the time of the initial treatments. On the top of the banks, the regrowth was short, sparse, and somewhat brown.

In the 1960 experiment, retreatments were made on April 17, June 28, and August 16, 1961, and on April 10 and July 6, 1962. In the 1961 experiment, retreatments were made on May 4 and August 6, 1962. In both experiments, final evaluations were made approximately 1 month after the last retreatments.

Results of Amitrole and Amitrole-T Treatments

Treatments started in the spring.—Within 1 month after the initial treatments, most of the top growth of reed canarygrass was bleached and stands were reduced (table 2). However, much of the undergrowth remained green even when the spray volume was increased from 80 g.p.a. in the 1960 experiment to 160 g.p.a. in the 1961 experiment. Apparently, the herbicides did not tranlocate well, and greater pressures were needed to provide adequate penetration and coverage of the dense foliage. New shoots of reed canarygrass emerged at and from below the waterline within the 1st month after the initial treatments.

Two months after the initial treatments, the reed canarygrass was about 60 inches tall and forming seed heads on untreated plots. At this time, amitrole compounds appeared somewhat less effective than dalapon in killing the undergrowth. New growth was developing from well below the waterline and in the 2- to 3-foot zone above the waterline. Other weeds such as hemp dogbane (*Apocynum cannabinum* L.), quackgrass (*Agropyron repens* (L.) Beauv.), and willow (*Salix* spp.) were also developing on a number of the treated plots.

When the first retreatments were made late in June, the reed canarygrass was growing vigorously and forming seed heads in the 3-foot zone immediately above the waterline. On the shoulder and top of the bank, much of the top growth was dead, but recovery of surviving growth was rapid.

The retreatments in June and August generally killed the foliar growth more rapidly and completely than the initial treatments (fig. 3). By fall, the stands

FIGURE 3.—Bleached reed canarygrass along irrigation canal after treatments with an amitrole compound. Foliage of treated canarygrass was generally killed more rapidly and completely by retreatments in June than by initial treatments in April.

were reduced 89 to 97 percent by the two highest rates of treatment. During the following spring, amitrole symptoms (bleaching) were still evident, particularly in the foliage on the shoulder and top of the bank. At the same time, stands were reduced >99 and 92 percent in the 1960 and 1961 experiments, respectively.

The reed canarygrass was not completely eliminated even after two or three retreatments during the 2d year. After a total of six treatments in the 1960

TABLE 2.—Reduction in stands of reed canarygrass evaluated after initial spring treatments and after retreatments with amitrole, amitrole-T, dalapon, and MH

Date of initial treatment and date of evaluation	Percentage of reduction[1] after treatment with—												Percentage of reduction[1] in check
	Amitrole at—			Amitrole-T at—			Dalapon[2] at—			MH[2] at—			
	4 lb./acre	8 lb./acre	12 lb./acre	2 lb./aere	4 lb./acre	6 lb./acre	15 lb./acre	20 lb./acre	25 lb./aere	4 lb./aere	6 lb./aere	8 lb./acre	
April 18, 1960:													
May 18, 1960	66	71	47	20	29	39	67	74	76	0	0	0	-6
June 29, 1960[3]	6	33	43	23	29	20	46	39	27	5	2	5	-7
July 18, 1960	61	80	86	73	81	83	78	85	78	8	11	9	-7
Aug. 22, 1960[3]	30	60	83	29	58	41	40	33	37	2	5	-6	-6
Sept. 23, 1960	86	94	94	87	91	91	90	92	94	-1	2	-6	-6
Apr. 14, 1961[3]	54	98	>99	63	97	98	90	91	94	27	35	31	6
May 16, 1961	84	99	>99	92	99	99	92	89	88	26	30	29	2
June 29, 1961[3]	52	97	>99	71	96	98	80	79	73	51	55	45	-10
July 28, 1961	84	>99	>99	89	89	>99	90	92	94	11	30	39	-12
Aug. 16, 1961[3]	73	98	99	83	97	>99	82	85	84	-2	11	12	-15
Sept. 19, 1961	90	99	>99	93	>99	>99	90	92	94	12	6	5	-20
Oct. 16, 1961	92	>99	>99	92	>99	>99	92	95	91	24	17	5	-20
Apr. 23, 1962[3]	80	>99	>99	79	97	>99	94	89	91	15	63	44	11
June 13, 1962	52	98	>99	77	96	98	86	86	82	2	18	32	-20
July 6, 1962[3]	46	>99	>99	73	>99	>99	72	79	79	-1	-6	3	-16
Aug. 10, 1962	48	99	>99	76	>99	>99	84	86	84	1	-1	-16	-21
April 14, 1961:													
May 16, 1961	56	64	51	27	33	45	37	48	52	----------	----------	----------	-10
June 28, 1961[3]	0	37	51	6	24	59	41	23	63	----------	----------	----------	-21
July 28, 1961	31	76	88	49	76	86	65	76	85	----------	----------	----------	-23
Aug. 15, 1961[3]	7	49	82	13	56	84	37	35	70	----------	----------	----------	-30
Sept. 19, 1961	49	90	95	65	79	97	65	74	82	----------	----------	----------	-30
Oct. 16, 1961	60	90	95	83	89	97	71	79	81	----------	----------	----------	-33
Apr. 12, 1962[3]	37	90	92	45	82	89	71	73	81	----------	----------	----------	8
May 17, 1962	81	99	98	86	99	>99	76	84	91	----------	----------	----------	-14
July 3, 1962[3]	-6	90	94	0	89	96	-30	-6	43	----------	----------	----------	-32
Aug. 10, 1962	-10	94	95	14	89	99	0	6	45	----------	----------	----------	-34

[1] Negative values indicate increase in test stands.

[2] 2,4-D at 2 lb./aere was included in these treatments.

[3] Retreatments as well as evaluations were made on these dates.

experiment, a few shoots survived at or near the waterline on plots treated at the two highest rates.

After five treatments in the 1961 experiment, most of the surviving or new growth was on the berm, which was saturated continuously and covered frequently with 1 to 2 inches of water during the irrigation season. Such saturation and inundation undoubtedly accounted for the somewhat poorer results obtained in this experiment than in the 1960 experiment, which was conducted along a channel that was V-ditched each year and contained no berm.

Before the fourth retreatments were applied on June 29, 1961, or July 3, 1962, the plots were clipped at a height of about 12 inches to remove the rank growth of annual and perennial broad-leaved weeds. Such weeds were especially dense where the reed canarygrass had been nearly eliminated. The retreatments in April did not control broad-leaved weeds that emerged later in the spring. The retreatment schedule for controlling reed canarygrass in this experiment obviously did not completely coincide with a schedule needed to adaquately control broad-leaved weeds. Therefore, an additional treatment with 2,4-D alone, particularly during late May, to control such weeds undoubtedly would have been worthwhile.

Retreatments in April and July of the 3d year of the 1960 experiment again controlled, but did not completely eliminate, reed canarygrass at the waterline on plots treated with the two highest rates of amitrole or amitrole-T.Unfortunately, the occasional surviving shoots were ready sources of spread. Amitrol-T at 4 pounds per acre per treatment was as effective as any other treatment. The amitrole herbicides were superior to dalapon at the higher rates in these experiments.

Treatments started in the fall.—Characteristic symptoms (bleaching) were still evident in the spring regrowth of reed canarygrass after the initial amitrole treatments applied during the previous fall. Suppression of the regrowth was especially apparent on the shoulder and top of the bank. The first retreatments were not considered necessary until as late as May 4 in the 1961 experiment.

In the experiment started in the fall of 1960 with retreatments in April, June, and August, 1961, the first four treatments with amitrole at 8 pounds or amitrole-T at 4 pounds per acre reduced stands as much as the first six treatments in the experiment started in the spring of 1960 (tables 2 and 3). Although a greater degree of control was reached early in the season in the experiment initiated in the spring, the fall treatment of reed canarygrass still appeared to be the more effective. Similar trends have been found in the herbicidal treatment of perennial broad-leaved weeds.

Regrowth on treated plots was primarily at and immediately above the waterline, and it appeared healthy and vigorous. On the shoulder and top of the bank, regrowth was scattered, rather sparse, and somewhat bleached.

After two more retreatments in 1962 (total of six treatments), reed canarygrass was apparently eliminated on the shoulder and top of the bank. A few shoots reemerged at the waterline.

Stands were reduced less by the treatments in the 1961 experiment than by those in the 1960 experiment. However, suppression of the growth was more pronounced. The two retreatments in the 1961 experiment suppressed the growth of reed canarygrass almost as effectively as the first three retreatments in the previous experiment.

Amitrole-T at 4 pounds per acre was just as effective as amitrole at 8 pounds per acre. Both compounds were superior to dalapon at 20 pounds per acre as the experiments progressed. Comparatively, dalapon seemed more effective under cool temperatures whereas the amitrole compounds seemed more effective under warm temperatures. In Montana, Hodgson (*2*) found that dalapon at 20 pounds per acre was more effective in controlling reed canarygrass than amitrole-T at 5 pounds per acre. The growth of reed canarygrass is undoubtedly influenced by prevailing temperatures, and the temperature-related activity within the plant may well be associated with the effectiveness or noneffectiveness of the dalapon and amitrole treatments.

Results of Dalapon Treatments

Treatments started in the spring.—Dalapon killed much of the top growth of reed canarygrass and reduced stands within 1 month after treatment (table 2). However, much of the undergrowth remained green, even in the 1961 experiment in which the volume of spray was increased from 80 to 160 g.p.a. Apparently, downward translocation of the herbicide was lacking, and pressures were not high enough to provide adequate penetration and thorough coverage of the dense foliage. Recovery of the reed canarygrass was more rapid and regrowth was more prevalent in the zone immediately above the waterline than on the shoulder and top of the bank.

Two months after the initial treatments, dalapon at the 20- or 25-pound rate had killed a high percentage of the foliage, even though some green undergrowth remained. New growth continued to develop from below the waterline as well as in the 2-

TABLE 3.—*Reduction in stands of reed canarygrass evaluated after initial fall treatments and after retreatments with amitrole, amitrole-T, dalapon, and MH*

Date of initial treatment and date of evaluation	Percentage of reduction[1] after treatment with—				Percentage of reduction[1] in check
	Amitrole at 8 lb./acre	Amitrole-T at 4 lb./acre	Dalapon at 20 lb./acre[2]	MH at 6 lb./acre[2]	
October 17, 1960:					
Mar. 15, 1961	53	75	>99	72	12
Apr. 17, 1961[3]	54	73	90	69	10
May 16, 1961	89	91	95	72	0
June 28, 1961[3]	76	85	89	34	-7
July 28, 1961	93	96	94	34	-7
Aug. 16, 1961[3]	93	91	92	28	-18
Sept. 19, 1961	94	97	95	31	-26
Oct. 16, 1961	97	>99	95	34	-29
Apr. 10, 1962[3]	87	87	86	51	26
May 17, 1962	>99	99	94	49	0
July 6, 1962[3]	94	96	84	38	-21
Aug. 3, 1962	99	>99	83	20	-32
October 5, 1961:					
Oct. 16, 1961	11	1	16	----------	0
Apr. 23, 1962	47	73	87	----------	64
June 13, 1962[4]	89	98	91	----------	55
Aug. 6, 1962[3]	64	86	67	----------	49
Sept. 13, 1962	89	88	64	----------	23

[1] Negative values indicate increase in test stands.

[2] 2,4-D at 2 lb./acre was included in these treatments.

[3] Retreatments as well as evaluations were made on these dates.

[4] Retreatments were made on May 4, 1962, rather than on June 13, 1962.

to 3-foot zone immediately above the waterline. Reed canarygrass on untreated plots was about 60 inches high and forming seed heads.

When the first retreatments were made near the end of June, reed canarygrass was growing vigorously and some seed heads were forming in the 3-foot zone immediately above the waterline. On the shoulder and top of the bank, the results varied. Some of the top growth appeared dead, whereas other top growth was recovering rapidly.

The retreatments in June and August reduced the stands 71 to 94 percent by fall. The effects of the dalapon retreatments were rather peculiar inasmuch as the resultant composition was a mixture of partially and completely desiccated initial growth and vigorous regrowth 4 to 12 inches high.

In mid-April of the following year, density values on plots treated with dalapon were almost identical to those recorded the previous fall. Dalapon symptoms were still evident in the foliage, particularly that growing on the top of the bank. Most of the surviving growth was in the 2- to 3-foot strip immediately above the waterline. The dalapon treatments the previous year delayed the regrowth of some reed canarygrass because healthy, young shoots continued to emerge for at least 1 month after the retreatments in mid-April.

The two or three retreatments during the 2d year did not further reduce the stands appreciably. In fact, the dalapon was particularly ineffective in the 1961 experiment. In that experiment, much of the growth was on a 2-foot berm that was saturated continuously and inundated frequently with 1 to 2 inches of water during the irrigation season.

Dalapon plus 2,4-D did not adequately control the annual and perennial broad-leaved weeds that invaded the plots as the reed canarygrass stands were reduced.

After a total of eight treatments in the 3 years of the experiment started in 1960, dalapon reduced the stand of reed canarygrass about 85 percent. Most of the surviving growth was in the 3-foot zone immediately above the waterline. In this particular experiment, dalapon was no more effective at 25 than at 15 or 20 pounds per acre.

Treatments started in the fall.—Fall applications of dalapon appreciably delayed regrowth or reemergence of reed canarygrass the following spring. As observed in March and April, initial fall treatments appeared far more effective than initial spring treatments in reducing the stands of reed canarygrass (table 3). Moreover, retreatments after initial fall treatments maintained a higher degree of control than

a comparable number of retreatments applied after initial spring treatments. The results tend to agree with those obtained by Hodgson *(2)* in Montana.

As in other experiments, vigorous regrowth on dalapon-treated plots was primarily at and immediately above the waterline. On the shoulder an top of the bank, regrowth was somewhat sparse but exhibited no visible symptoms of dalapon injury.

Despite the greater effectiveness of the dalapon treatments early in the experiments, such treatments again appeared inferior to the amitrole treatments. More growth persisted at or near the waterline and reed canarygrass was not eliminated on the shoulder and top of the bank.

The greatest problem area along an irrigation system obviously is at or near the waterline. None of the treatments in these experiments completely eliminated reed canarygrass from that area (fig. 4). It

FIGURE 4.—A few shoots reemerged at normal waterlines of irrigation lateral after the reed canarygrass stand was almost completely eliminated by repeated applications of amitrole-T at 4 pounds per acre. Reemergent shoot is shown in the hand of figure in photograph.

cannot be overemphasized that a few surviving plants at the waterline are a ready source of emanation and rapid spread.

Results of MH Treatments

Treatments started in the spring.— One month after the initial spring treatment in 1960, top growth of reed canarygrass was suppressed on all treated plots. However, stands were not reduced (table 2).

Two months after the initial treatment, MH, particularly at the 6- and 8-pound rates, maintained complete suppression of the reed canarygrass except in the 2- to 3-foot zone immediately above the waterline. New growth was emerging from below the waterlinc. At the same time, reed canarygrass on untreated plots was about 60 inches tall and forming seed heads.

Just before the first retreatments near the end of June, some of the top growth was not only suppressed, but was severely injured. Other top growth recovered rapidly. Regrowth was particulary vigorous and some seed heads developed in the 3-foot zone immediately above the waterline.

The June and August retreatments in 1960, especially those at the 6- and 8-pound rate, somewhat suppressed the growth of reed canarygrass in the 3-foot zone above the waterline. These retreatments also browned much of the leaf growth on the shoulder and top of the bank. Stands were not reduced appreciably.

After three additional retreatments in 1961 and two in 1962, MH proved impractical for suppressing the growth of reed canarygrass along irrigation systems, particularly in the 2- to 3-foot zone immediately above the waterline.

Treatments started in the fall.—Initial fall treatments with MH plus retreatments appreciably reduced stands of reed canarygrass on the shoulder and top of the bank (table 3). However, such treatments did not suppress reed canarygrass satisfactorily in the zone immediately above the waterline. Frequent hand scything was necessary to prevent extension of the profuse growth into the water.

Dalapon for Suppression of Reed Canarygrass

Dalapon was applied to reed canarygrass along Lateral 4 Extension at 5, 10, or 15 pounds per acre on April 12, 1962. Water was used as the diluent at the rate of 80 g.p.a. Irrigation water had been turned into the lateral about 1 week before the treatments. The reed canarygrass, 4 to 16 inches high, was rather dense and growing rapidly. As a result of reed canarygrass growth, a berm 20 to 24 inches wide had developed at the waterline and was included in the plot area.

Plots initially treated at the rates of 5 or 10 pounds per acre were retreated on June 1, 1962. Those treated at 15 pounds per acre were not retreated until June 13, 1962. The experiment was discontinued on August 10, 1962.

Results of Treatments

Applications of dalapon at 5, 10, or 15 pounds per acre did not suppress the growth of reed canarygrass satisfactorily, especially on the berm and

immediately above the waterline. The 5-pound treatments suppressed reed canarygrass little, if any. The percentage of increase in initial stands was greater on plots treated at 5 pounds per acre than on untreated plots (table 4). Treatments at 5 pounds per acre may have induced the development of a greated number of shoots.

Dalapon at 10 pounds per acre suppressed the growth of reed canarygrass noticeably on the shoulder and top of the bank. However, the growth on the berm and immediately above the waterline was not suppressed adequately.

The 15-pound-per-acre rate of dalapon suppressed the growth of reed canarygrass 1 to 2 weeks longer than the 10-pound rate. However, numerous retreatments would undoubtedly be necessary to maintain satisfactory suppression on the berm and immediately above the waterline during the irrigation season.

Dalapon in Different Spray Volumes

On April 14, 1961, 20 pounds of dalapon plus 2 pounds of 2,4-D were applied in 40, 80, 160, and 320 gallons of water per acre to reed canarygrass along Lateral 4 Extension. The reed canarygrass was dense and 3 to 18 inches tall. A 24-inch berm supported over 25 percent of the reed canarygrass growth in the test plots. Irrigation water had been turned into the lateral about 10 days before the treatments.

Retreatments were made on June 28 and August 15, 1961, and on April 11 and July 3, 1962. The experiment was discontinued on August 10, 1962.

Results of Treatments

Regardless of the volume of the spray applied to the reed canarygrass, the stands were affected almost equally by the five applications of dalapon at 20 pounds per acre (table 5). Although the higher volumes covered and wetted the foliage more thoroughly, the meristematic regions of much of the reed canarygrass were apparently well protected from such sprays.

The 24-inch berm was exposed to shallow inundation for various periods during the experiment. The reduction in stands of reed canarygrass on the berm was less than that normally expected from spring or summer applications of dalapon to reed canarygrass on bermless ditchbanks. Thus, the overall percentages of reduction were lower than usual.

Dalapon Plus Adjuvants

Early in 1962, plots were laid out along Lateral 4 Extension. Dalapon at 20 pounds in 100 gallons of water per acre was applied initially on April 12 with various adjuvants that included kerosene, kerosene-surfactants, and other surfactant formulations listed in table 6. At the time of the initial applications, water was in the channel and the reed canarygrass averaged 10 inches high. No retreatments were made and the experiment was discontinued on June 29, 1962.

Results of Treatments

No differences were found in the effectiveness of the treatments (table 6). The high variability within treatments may have accounted for the lack of differences in treatment results.

According to Freed and Montgomery (*1*), there is some indication of highly specific requirements for a surfactant formulation to fit the herbicide in order to achieve maximum effectiveness. Jansen, Gentner, and Shaw *(3)* found that surfactants exhibited three characteristic types of action on herbicidal activity. Most commonly, progressive enhancement of herbicidal activity was obtained with logarithmic increases in surfactant concentrations. Some surfactants brought about progressive suppression of the herbicidal activity, and still others were ineffective in changing the level of activity attributable to the herbicide alone. Leasure *(4)* increased the translocation

TABLE 4.—Increase or decrease in reed canarygrass ground cover after initial spring treatments and after retreatments with dalapon[1]

Date of treatment and retreatment	Amount applied	Increase (+) or decrease (-) in initial ground cover on—		
		May 17, 1962	June 13, 1962	Aug. 10, 1962
	Lb./acre	*Percent*	*Percent*	*Percent*
April 12, 1962----------	0	+57	+149	+168
April 12, 1962; retreatment June 1---	5	+112	+172	+280
April 12, 1962; retreatment June 1---	10	-29	-6	+183
April 12, 1962; retreatment June 13-	15	-47	+66	+175

[1] 2,4-D at 2 pounds per acre was included in the treatment.

TABLE 5.—*Reduction in stands of reed canarygrass evaluated after initial spring treatments and after retreatments with dalapon at 20 lb./acre in different spray volumes*[1]

Date of initial treatment and date of evaluation	Percentage of reduction after applications of dalapon in spray volumes of—			
	40 gal./acre	80 gal./acre	160 gal./acre	320 gal./acre
April 14, 1961:				
May 16, 1961 ---	15	13	15	18
June 28, 1961[2]--	43	15	12	27
July 28, 1961 ---	74	66	57	69
Aug. 15, 1961[2]--	23	18	5	27
Sept 19, 1961 ---	66	66	69	69
Oct. 16, 1961 ---	77	73	80	78
Apr. 11, 1962[2]--	66	60	69	58
May 17, 1962 ---	82	75	85	82
July 3, 1962[2]----	0	6	[3]-5	4
Aug. 10, 1962---	23	0	20	40

[1] 2,4-D at 2 pounds per acre was included in the treatments.
[2] Retreatments as well as evaluations were made on these dates.
[3] Negative value indicates increase in test stands.

of dalapon in uniform quackgrass plants (*Agropyron repens* (L.) Beauv.) with nonionic wetting agents under controlled conditions and by avoiding certain variables encountered in the field. When additional surfactant was added to the spray solution, McWhorter *(5)* increased johnsongrass control with dalapon at rates of 2 to 8 pounds per acre, but control apparently was not increased at 10 to 20 pounds per acre. Comes[3] apparently increased the effectiveness of dalapon at 20 pounds per acre by treating reed canarygrass during May rather than in early April and by adding a surfactant (alkylarylpolyoxyethylene glycols, free fatty acids, and isopropanol or alkylarylpolyoxyethylene glycols, mixed petroleum distillates, alkyl amine acetate, alkylarylsulfonates, and polyhydric alcohol) at the rate of 3 pints per 100 gallons of spray solution (0.375 percent). Thus, early-spring applications, fairly high rate of dalapon, and rather low concentrations of adjuvant by 1972 standards may account for some of the nonsignificant differences between treatments in this experiment.

Date of Applying Amitrole-T

Plots 4 1/8 feet wide by 16 1/2 feet long were laid out on the north bank of Lateral 4 Extension early in 1963. Initial applications of amitrole-T at 4 pounds per acre (amitrole basis) were made on April 1 and at weekly intervals thereafter until about June 1. Water at 160 g.p.a. was used as the diluent. Retreatments were made as necessary to maintain satisfactory suppression or control of the reed canarygrass during 1963. Canarygrass control on the plots was periodically evaluated during 1963 and finally in May 1964.

Results of Treatments

Plots treated initially during the first half of April (reed canarygrass in three to eight-leaf stage and averaging 7 to 17 inches tall) were retreated twice during the season to maintain satisfactory suppression or control. (Suppression or control was considered satisfactory in this experiment as long as regrowth did not interfere with waterflow or the carrying capacity of the channel.) Only one retreatment was necessary to maintain satisfactory control when initial treatments were made at weekly intervals from April 22 to May 27.

When the treatments were made on May 27, the reed canarygrass averaged over 4 feet in height, had formed seed heads, and extended into the water. The effects of the late treatments on the reed canarygrass were different than those of the earlier treatments. The plants were stunted and the leaves were somewhat browned rather than bleached. The sprayed foliage was not desiccated but its growth was inhibited during the remainder of the season. Some new shoots emerged and developed at the waterline after mid-July, and a retreatment was necessary on August 1. Discoloration and desiccation of top growth was more pronounced and regrowth developed more rapidly when initial treatments were made on May 13 or May 20.

The optimum date for initially applying amitrole-T was about May 1, when the reed canarygrass was approximately 3 feet tall at the waterline and still in the

[3]Bruns, V.F., and Comes, R.D. 1967 Annual Report. Weed Investigations, Plant Sci. Res. Div., U.S. Dept. Agr., in coop. with Wash. Agr. Expt. Stas., Irr. Agr. Res. and Ext. Center, Prosser. 1967.

preheading stage. The effectiveness of initial treatments diminished when they were applied after seed heads began to develop.

Three amitrole-T treatments (initial plus two retreatments) during 1963 reduced the stands of reed canarygrass by almost 50 percent, whereas stands were not reduced appreciably after two treatments (initial plus one retreatment) were applied (table 7). This result should be considered in programs aimed at reducing or eliminating reed canarygrass with amitrole-T.

Application Rates of Sodium Salt and Ester of TCA

On October 21, 1960, the sodium salt of TCA was applied at 100,130, and 160 pounds per acre to the north bank of Lateral 4 Extension 395. Water was used as the diluent at 160 g.p.a. No surfactant was added to the sprays. The reed canarygrass and other growth was mowed close to the ground and removed just before the treatments.

All plots were seeded with a mixture of redtop

TABLE 6.—Control of reed canarygrass evaluated after treatments on April 12, 1962, with dalapon at 20 pounds in 100 gallons of water per acre with and without the addition of adjuvants

Adjuvant	Total concentration	Control above (+) or below (-) that obtained with no adjuvant on—	
		June 1	June 29
	Pct. vol./vol.	*Pct.*	*Pct.*
No adjuvant[1]	----------	0	0
Kerosene	0.5	+3	+10
Kerosene at 0.5 pct. vol./vol. plus calcium dodecylbenzene sulfonate + mixture of nonylphenol ethylene oxide at 0.008 pct. vol./vol.	.508	0	-9
Kerosene at 0.5 pct. vol./vol. plus sodium dioctyl sulfo-succinate at 0.06 pct. vol./vol.	.56	+13	-1
Sodium dioctyl sulfo-succinate	.06	-7	-8
Do	.125	-4	-9
Alkylarylpolyoxyethylene glycols, free fatty acids, and isopropanol (blended, nonionic).	.06	+30	+9
Do	.125	+6	-6
Tridecylalcohol-ethylene oxide adduct:			
1:6 mole	.06	-14	-5
1:6 mole	.125	0	-1
1:7 mole	.06	-24	-10
1:7 mole	.125	-14	-9
1:8 mole	.06	+3	+2
1:8 mole	.125	-17	+12
1:9 mole	.06	-7	+4
1:9 mole	.125	+10	+4
Emulsifiable A-C polyethylene, fatty acid-amine condensate, alkylaryl sulfonate (blended).	.06	0	-7
Do	.125	+6	-7
Alkylaryl polyether alcohol (nonionic)	.06	-20	-1
Do	.125	-7	+10
Polyoxyethylene sorbitan monolaurate (nonionic).	.06	+3	-7
Do	.125	+3	+9
Petroleum sulphonates, free and combined fatty acids, and petroleum oil (anionic).	.06	+3	-1
Do	.125	-4	+1

[1]Absolute reed canarygrass control averaged 47 and 13 percent on June 1 and June 29, respectively.

(*Agrostis alba* L.), Kentucky bluegrass (*Poa pratensis* L.), and crested wheatgrass (*Agropyron cristatum* (L.) Beauv.) on March 15, 1961. The soil surface was handraked after seeding. The experimental area was sprayed with 2,4-D as necessary to control broad-leaved weeds after the seeded grasses were established.

On October 20, 1961, another series of plots was treated along Drain Spur 53. The sodium salt of TCA was applied at 100, 130, and 160 pounds in 100 gallons of water per acre. The ester of TCA was applied at 12.5, 25, and 50 pounds in 100 gallons of water per acre and also in 100 gallons of diesel oil per acre. The ditchbank was mowed and the reed canarygrass and other debris removed before the treatments.

Redtop, Kentucky bluegrass, and crested wheatgrass were seeded over the plot area on March 7, 1962. Plots treated with the ester of TCA were retreated on July 3, and the experiment was abandoned on August 10.

Results of Sodium Salt of TCA Treatments

Unusually wet weather during the winter and spring after the 1960 treatments was highly conducive to the movement of the sodium salt of TCA into and beyond the root zone of the reed canarygrass and to the establishment of the desirable grasses seeded on March 15, 1961. Seedlings of Kentucky bluegrass, redtop, and crested wheatgrass began to emerge on the treated plots on April 3. Dense stands of the grasses had developed by May 16, especially along the shoulder from the waterline to the top of the canal bank.

Complete or nearly complete control of reed canarygrass was maintained by the treatments throughout the spring of 1961 (table 8). Under the highly favorable conditions of the experiment, the 100-pound rate of sodium salt of TCA was almost as effective as the 130- or 160-pound rates. However, during the summer, some scattered new growth of reed canarygrass appeared at or just below the waterline. Clipping and 2,4-D sprays were used as supplemental means for controlling broad-leaved weeds on the experimental plots.

In April 1962, regrowth of reed canarygrass on treated plots occurred for the most part at and immediately above the waterline. A few scattered shoots also emerged farther up the slope and near the top of the bank, even though the stand of desirable grasses was dense. By June 28, the scattered reed canarygrass plants along the waterline were growing profusely, had headed, and had lodged and spread in the water.

TABLE 7.—Reduction in stands of reed canarygrass evaluated after initial spring treatments and after retreatments with amitrole-T at 4 lbs./acre

Date of evaluation	Percentage of reduction[1] in check	Percentage of reduction[1] after treatments started on—								
		Apr. 1	Apr. 8	Apr. 16	Apr. 22	Apr. 29	May 8	May 13	May 20	May 27
Apr. 8, 1963	-1	0								
Apr. 16, 1963	-2	36	4							
Apr. 22, 1963	0	59	44	3						
Apr. 29, 1963	-1	74	56	41	3					
May 8, 1963	-1	89	84	59	24	0				
May 13, 1963	-4	94	87	67	34	14	-1			
May 20, 1963	-8	91	93	74	60	29	19	4		
May 27, 1963	-8	76	92	77	69	32	27	14	6	
June 4, 1963	-8	72	87	85	86	40	32	17	9	7
June 10, 1963	-8	[2] 42	71	61	71	47	28	24	16	12
June 20, 1963	-8	53	[2] 29	32	51	53	41	27	22	12
June 25, 1963	-8	72	44	[2] 41	61	59	54	26	17	12
July 9, 1963	-8	83	68	71	[2] 27	[2] 43	41	28	39	16
July 23, 1963	-8	86	82	93	69	89	[2] 43	[2] 53	32	16
Aug. 1, 1963	-8	78	72	87	72	93	66	67	[2] 21	[2] 12
Aug. 20, 1963	-8	39	55	67	71	84	84	83	60	57
Sept. 9, 1963	-8	[2]9	[2] 18	23	51	70	70	80	70	65
Sept. 17, 1963	-8	28	24	[2] 10	19	59	59	70	65	58
Sept. 24, 1963	-8	48	35	26	17	54	52	70	63	57
Oct. 15, 1963	-8	56	45	52	9	37	25	27	27	14
May 22, 1964	-8	32	53	47	0	-4	-5	0	0	3

[1] Negative values indicate increase in test stands.

[2] Retreatments were also made on the specified date of evaluation.

TABLE 8.—*Reduction in stands of reed canarygrass evaluated after initial treatments with the sodium salt of TCA on October 21, 1960*

Date of evaluation	Reduction after applications of sodium salt of TCA at—		
	100 lb./acre	130 lb./acre	160 lb./acre
	Percent	*Percent*	*Percent*
Mar. 15, 1961 --	>99	100	100
May 16, 1961---	>99	100	>99
June 28, 1961---	>99	>99	>99
July 28, 1961 ---	97	>99	97
Aug. 14, 1961 --	95	98	95
Sept. 19, 1961 --	91	96	94
Oct. 16, 1961 ---	91	95	93
Apr. 10, 1962---	89	89	91
May 17, 1962---	75	80	82
June 29, 1962---	62	72	81
Aug. 3, 1962 ----	70	72	81

The growth that extended into the water was cut back with handscythes to prevent clogging of the channel and impeding the water flow.

Excellent stands and growth of desirable grasses persisted on the treated plots during 1963. The growth of reed canarygrass on such plots was still confined largely to the area along the waterline and constituted only 10 to 15 percent of the ground cover. However, the problem was still as serious on the treated plots as it was on the untreated plots, where reed canarygrass constituted 75 to 95 percent of the ground cover. In both cases, the most troublesome growth was at the waterline. From this area, the growth spread into the water, clogged the channel, and necessitated removal.

After the 1961 treatments, the weather was rather adverse when compared with the highly favorable weather after the 1960 treatments. The ground was frozen within 2 to 3 weeks after the herbicide applications. Precipitation between October 1, 1961, and April 1, 1962, totaled only 3.54 inches as compared with 5.48 inches for the same period the previous year. For 6 weeks after seeding of redtop, Kentucky bluegrass, and crested wheatgrass, the weather was abnormally dry. Seven light showers during the period totalled only 0.52-inch of rainfall. As a result, the sodium salt of TCA treatments were somewhat less effective on reed canarygrass in the 1961 experiment than in the 1960 experiment (tables 8 and 9). Moreover, no seedlings became established or were even noted after seeding of the desirable grasses on March 7, 1962.

Results of Ester of TCA Treatments

Under the adverse weather conditions of early freezing and below normal precipitation, the October treatments with the ester of TCA at 12.5 to 50 pounds per acre in 1961 plus retreatments in July 1962 did not effectively control reed canarygrass when applied either with water or with diesel oil (table 9). Split applications of the ester of TCA at 50 pounds per acre each were not as effective as a single application of sodium salt of TCA at 100 pounds per acre in the same experiment. No seedlings of Kentucky bluegrass, redtop, or crested wheatgrass were observed in the treated areas.

Application Rates of Paraquat and Diquat Alone or in Combination

The foliage of reed canarygrass along Lateral 4 Extension was treated on April 14, 1961, with paraquat at 1, 2, 4, or 6 pounds per acre, diquat at 2, 4, or 6 pounds per acre, and a 50:50 mixture of paraquat and diquat at 2 pounds per acre. Water was used as the diluent at 160 g.p.a. The reed canarygrass was dense, luxuriant, and 3 to 18 inches high (average 12 inches) at the time of the initial treatment. Plots initially treated with paraquat alone at 2, 4, or 6 pounds per acre were the only plots retreated on May 18, 1961.

Results of Paraquat Treatments

Paraquat at 2, 4, or 6 pounds per acre killed the foliage of most of the young reed canarygrass. Five weeks after the initial treatments on April 14, considerable new growth had developed, but the stands were noticeably reduced (table 10).

Retreatments on May 18 were somewhat less effective than the initial treatments, and recovery of the reed canarygrass was nearly complete within a month.

Paraquat at 1 pound per acre was ineffective. None of the treatments appeared practical for controlling sizeable infestations of reed canarygrass along irrigation systems.

Results of Diquat Treatments

Diquat at 2, 4, or 6 pounds per acre was highly phytotoxic and turned the foliage of reed canarygrass brown within 1 or 2 days after treatment. However, control of the reed canarygrass was only temporary at all rates of application. Within 4 weeks, the plants sent forth new growth, and all symptoms of injury disappeared and recovery was complete (table 10).

In comparison, diquat at 2, 4, or 6 pounds per acre was considerably less effective in controlling reed canarygrass than paraquat at 2 pounds per acre.

TABLE 9.—Reduction in stands of reed canarygrass evaluated after treatments with the sodium salt and ester[1] of TCA on October 20, 1961

TCA formulation	Amount applied		Type of diluent	Reduction on—		
	Per treatment	Total		Apr. 23, 1962	July 3, 1962	Aug. 10, 1962
	Lb./acre	*Lb./acre*	*100 gal./acre*	*Percent*	*Percent*	*Percent*
Sodium salt	100	100	Water	100	91	88
Do	130	130	---do---	>99	93	86
Do	160	160	---do---	100	>99	92
Ester	12.5	25	---do---	63	[2]-11	0
Do	25	50	---do---	93	56	40
Do	50	100	---do---	>99	56	66
Do	12.5	25	Diesel oil	74	0	4
Do	25	50	---do---	>99	73	80
Do	50	100	----do---	>99	67	80

[1] Plots treated with the ester of TCA were retreated on July 3, 1962.
[2] Negative value indicates increase in stand.

Results of Treatments With Paraquat-Diquat Combination

A 50:50 mixture of paraquat and diquat at 2 pounds per acre was as ineffective as paraquat alone at 1 pound per acre (table 10). However, the mixture retarded the spread of reed canarygrass more effectively than diquat alone at 2, 4, or 6 pounds per acre.

Persistent Herbicides Applied to the Soil

This experiment was conducted to evaluate the effect of single applications of persistent herbicides applied to eradicate scattered clumps of reed canarygrass along newly infested ditchbanks, or to eradicate dense infestations of reed canarygrass along ditchbanks not susceptible to extensive erosion and with limited access.

On December 12, 1962, plots were laid out on the east bank of Drain Spur 53 and herbicides were applied as follows:

- Atrazine at 20, 40, or 80 pounds per acre.
- Dicamba at 10, 20, or 40 pounds per acre (acid equivalent).
- Dichlobenil at 10, 20, or 40 pounds per acre.
- Diuron at 20, 40, or 80 pounds per acre.
- Fenac at 10, 20, or 40 pounds per acre (acid equivalent).
- Isocil at 10, 20, or 40 pounds per acre.
- Monuron at 20, 40, or 80 pounds per acre.
- Simazine at 20, 30, or 60 pounds per acre.

Water was used as the diluent at 160 g.p.a. Before the treatments, reed canarygrass and other vegetative residue and debris were removed from the plot area as completely as possible by burning or through mechanical means. No water was present in the lateral at the time of the treatments. The lower edge of the plots began about 1 foot below the normal waterline.

Despite handraking and burning operations, considerable residue or debris remained on the plots at the time of treatment (Dec. 12, 1962). However, weather and moisture conditions in the area during the winter and spring after the applications were considered ideal for persistent herbicide treatments. During March, April, and May 1963, rainfall (3.28 inches) was above average. Annual precipitation (8.13 inches) was also above average.

In 1964, the spring and summer months were extremely dry. Only 0.77-inch of precipitation fell during the first 5 months of the year.

Results of Treatments

Atrazine at 40 or 80 pounds per acre was outstanding. Chlorosis was pronounced early in 1963 on plots treated at 20 pounds per acre. However, the reed canarygrass recovered and the percentage of ground cover was nearly normal by late September (table 11).

TABLE 10.—Increase or decrease in stands of reed canarygrass after foliar treatments with paraquat and diquat on April 14, 1961

Type of herbicide	Amount applied		Increase (+) or decrease (-) on—	
	Per treatment	Total	May 16, 1961	June 28, 1961
	Lb./acre	*Lb./acre*	*Percent*	*Percent*
Paraquat[1]	1	1	0	0
Do	2	4	-53	+4
Do	4	8	-53	-12
Do	6	12	-70	-3
Diquat	2	2	+6	+27
Do	4	4	0	+47
Do	6	6	0	+35
50:50 mixture of paraquat and diquat	2	2	-6	0
Untreated check	0	0	0	+19

[1] Plots initially treated with paraquat alone at 2, 4, or 6 pounds per acre were retreated on May 18, 1961.

TABLE 11.—*Reed canarygrass ground cover after soil treatments with persistent herbicides on December 12, 1962*

Herbicide and amount applied (lb./acre)	Canarygrass ground cover observed on—			
	April 22, 1963	Sept. 24, 1963	Apr. 6, 1964	July 22, 1964
	Percent	*Percent*	*Percent*	*Percent*
Atrazine:				
20	61	76	30	36
40	41	5	(1)	0
80	59	(1)	(1)	0
Dicamba:				
10	20	63	35	38
20	3	32	10	5
40	(1)	3	<1	(1)
Dichlobenil:				
10	80	98	45	69
20	70	99	52	84
40	32	89	38	67
Diuron:				
20	52	78	28	37
40	66	68	10	2
80	42	38	26	3
Fenac:				
10	47	69	47	46
20	55	71	48	64
40	34	71	22	58
Isocil:				
10	65	42	4	5
20	50	12	(1)	5
40	21	4	<1	0
Monuron:				
20	38	36	23	17
40	30	8	2	2
80	27	2	(1)	<1
Simazine:				
20	73	98	40	28
30	74	76	67	59
60	67	73	48	49

[1] Trace only of reed canarygrass was observed on this date.

Some chlorosis and reduction in ground cover was observed in 1964, but control was unsatisfactory. Atrazine at 40 pounds per acre reduced the ground cover to 5 percent by September 24, 1963, and to zero by July 22, 1964. On plots treated at 80 pounds per acre, only a trace of reed canarygrass (at the waterline) remained in September 1963, and none remained in July 1964 (fig. 5).

The herbicidal activity of dicamba on reed canarygrass was more rapid than that of any of the other herbicides tested during the experiment. During most of 1963, only a trace of reed canarygrass remained on the plots treated at 40 pounds per acre (table 11). Some regrowth, mostly at the waterline, was present on September 24. Apparently, the action of residual dicamba was responsible for again reducing the ground cover to a trace at the waterline on July 22, 1964. However, even a trace of survival at the waterline, the greatest problem area, represents a potential source of rapid reencroachment and spread.

Dicamba-treated plots on which reed canarygrass was eliminated, or nearly eliminated, became heavily infested with barnyardgrass (*Echinochloa crus-galli* (L.) Beauv.), wild oat (*Avena fatua* L.), and field bindweed (*Convolvulus arvensis* L.).

Dichlobenil did not injure reed canarygrass appreciably, even at 40 pounds per acre (table 11).

Diuron was somewhat less effective than monuron in eradicting reed canarygrass, but much more effective than simazine at the higher rates of application (table 11).

Fenac was less effective than simazine in controlling reed canarygrass (table 11). The results of the treatments were completely unsatisfactory.

FIGURE 5.—Reed canarygrass was eradicated within approximately 18 months after application of atrazine at the rate of 80 pounds per acre on December 12. The same result was obtained when atrazine or isocil was applied at the rate of 40 pounds per acre.

At equal rates, isocil was 2 or 3 times more effective than monuron in eliminating reed canarygrass (table 11). The 40-pound application in December 1962 eliminated all reed canarygrass by July 22, 1964.

At the higher rates, monuron was somewhat less consistent and effective than atrazine in eliminating the reed canarygrass (table 11). Even at 80 pounds per acre, monuron did not eliminate all plants at the waterline.

Simazine had no appreciable effect on the reed canarygrass in 1963 except for causing a slight chlorosis early in the season on plots treated at 60 pounds per acre. No reduction in ground cover was evident at the end of the season (table 11). In 1964, some chlorosis and reduction in stands were noted. However, all treatments were rather ineffective in controlling the reed canarygrass.

Persistent Herbicides Applied to the Foliage

Diuron at 4.8 or 9.6 pounds and bromacil at 2.4 pounds in 300 gallons of water per acre were applied to the foliage of reed canarygrass along Lateral 4 Extension on May 10, 1963. Surfactant (a mixture of alkylarylpolyoxyethylene glycols, free fatty acids, and isopropanol) was added to each treatment at the rate of 0.5 percent by volume of water. The sprays were applied with a 15-gallon power sprayer at a pressure of 100 p.s.i. through a two nozzle handboom. At the time of treatment, the reed canarygrass was growing luxuriantly, covered 98 percent or more of the ground, and ranged from 20 to 24 inches high on the shoulder of the bank and from 36 to 56 inches high near the waterline. The air temperature was 65° F.

Results of Treatments

The diuron-surfactant and bromacil-surfactant treatments were not effective in controlling reed canarygrass. From 2 to 3 weeks after the treatments, topkill averaged no more than 4 percent (table 12). Growth was not arrested appreciably, and seedheads continued to develop.

Twenty-five days after the treatments were applied, no differences between treated and untreated plots could be detected. Growth at the waterline necessitated removal with hand scythes. During the remainder of the season, the plot area was mowed by irrigation district personnel to maintain control of the reed canarygrass.

TABLE 12.—Topkill of reed canarygrass after foliar treatments with diuron and bromacil on May 10, 1963

Herbicide	Amount of spray components applied			Topkill evaluated on—	
	Herbicide	Water diluent	Surfactant (by vol.)	May 27, 1963	June 4, 1963
	Lb./acre	*Gal./acre*	*Percent*	*Percent*	*Percent*
Diuron ----	4.8	300	0.5	1	0
Diuron ----	9.6	300	.5	4	0
Bromacil--	2.4	300	.5	1	0

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